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## Production of indigenous alcoholic beverages in a rural village of Cameroon

Ryosuke Kubo, Shinya Funakawa, Shigeru Araki and Naofumi Kitabatake

### Abstract

In this study, the indigenous alcoholic beverages in a rural village of Cameroon were investigated. The technique for producing alcoholic beverages in the village was observed, and the concentrations of ethanol, glucose and lactic acid and the pH values during the course of production were measured using portable devices at the field site. Eight different kinds of alcoholic beverage (palm wine, palm spirits, raffia wine, cassava spirits, maize turbid beer, maize spirits, plantain wine and plantain spirits) were produced and consumed in the village. Of these beverages, palm wine, made from palm sap, was the most important alcoholic beverage in a villager's daily life. In addition, starch-based alcoholic beverages were distilled rather than drunk directly. As germinated maize, which has a relatively low amylase activity, was used as an amylase source in production, starch-based alcoholic beverages might need to be distilled to enhance the ethanol concentration. During the course of production, the pH was reduced using local techniques, which proved to be effective in preventing bacterial contamination.

**Keywords:** brewing; alcoholic beverage; africa; food culture

## Introduction

Alcoholic beverages are integral to daily life; alcohol has been consumed since prehistoric periods. Various types of local, traditional and indigenous alcoholic beverages (hereafter, indigenous alcoholic beverage) are produced from local foodstuffs using traditional and indigenous techniques. Currently, however, most alcoholic beverages (including beer, wine and whisky) that are industrially mass-produced are consumed in developed countries, and the production and consumption of indigenous alcoholic beverages is decreasing. Furthermore, the development of food transportation and preservation techniques has enabled not only the urban population, but also the rural population, to enjoy mass-produced alcoholic beverages. In addition, the rapid expansion of information technology has enabled the widespread use of most food manufacturing techniques worldwide. In spite of this situation, indigenous alcoholic beverages continue to be produced and consumed daily in sub-Saharan Africa and these beverages account for approximately 80% of the total consumption of alcoholic beverages (1).

In sub-Saharan Africa, finger millet and sorghum, particularly their germinated seeds, are used for the production of alcoholic beverages as the source of the saccharifying enzyme amylase. Cultivation of finger millet and sorghum appears to have originated in sub-Saharan Africa, and spread to East Asia (2, 3).

Finger millet is used in the production of alcoholic beverages in sub-Saharan Africa and East Asia (4). Because both finger millet and sorghum show high amylase activity (5) and degrade starch efficiently, these crops possess suitable properties for producing alcoholic beverages with high ethanol concentrations (data not presented). In sub-Saharan Africa, indigenous alcoholic beverages produced from finger millet and sorghum are not only luxuries, but are also important for nourishment, solidarity confirmation, religious rituals, remuneration for group labour work and cash income (6–10).

Root crops are important as staple foods as well as cereals in sub-Saharan Africa. In particular, root crops such as yam, taro and cassava have taken on an important role instead of cereals in sub-Saharan Central Africa (11). Cassava is widely cultivated and used as a staple food in the southeast region of Cameroon, a sub-Saharan Central African country. The southeast region of Cameroon lacks the cereal crops suitable for producing alcoholic beverages, and cassava, palm and maize are used for alcohol production. However, information about the production of alcoholic beverages in the root crop cultivating regions is limited compared with the cereal crop cultivating regions.

In this study, a fieldwork survey was conducted in a rural village in the southeast region of Cameroon, to clarify the manufacturing methods, including the raw materials and techniques used, and the properties of indigenous alcoholic beverages in a region lacking finger millet and sorghum, which are the crops typically used in the production of alcoholic beverages. In this rural village, cassava spirits and palm wine, in addition to palm spirits, raffia wine, maize turbid beer, maize spirits, plantain wine and plantain spirits, are produced and consumed. The interaction with and influence on other alcoholic beverage production methods and brewing are discussed in this paper.

## Methods

### *Field*

A field survey was conducted at a local village (Andom village, Lom-et-Djerem division, Cameroon) in an eastern province of Cameroon. This village is located on the southern plateau of Cameroon; the region surrounding the village is climatologically classified as the Derived Savanna, which was originally a forest. Annual rainfall in the region of this village is 1500–2500 mm and the altitude is 500–850 m (12). More than 2000 people inhabit this village and the livelihood of most villagers derives from agriculture and hunting. The primary crop cultivated in the village is cassava. Cassava stiff porridge (*ikéille pongo* in the local language) is the villagers' staple food. The field survey was carried out from September to December 2011.

### *Survey on the production of indigenous alcoholic beverages*

The production of indigenous alcoholic beverages such as palm wine, palm spirits, raffia wine, cassava spirits, maize turbid beer, maize spirits, plantain wine and plantain spirits, was surveyed and investigated. Villagers were interviewed, materials used in the production of alcoholic beverages were identified, manufacturing details were described and the weight and volume of the materials used in each step of production were measured. The experimental apparatus, instruments and devices were brought into the village, where the measurements and analysis were also carried out. Changes in the temperature of samples during distillation were measured using an infrared thermometer (826-T3; Testo, Kanagawa, Japan) during spirit production.

### *Measurement of ethanol, glucose and lactic acid concentration, and the pH of the indigenous alcoholic beverages*

Ethanol, glucose and lactic acid concentrations and the pH values of samples



were measured at the field site in the local village as follows. Samples were collected and immediately centrifuged at 241g for 3 min using a hand-powered centrifuge (hand-powered centrifuge, AS ONE Corp., Osaka, Japan) to obtain the supernatant, which was successively filtered through filter paper (Qualitative Filter Paper no. 2; Toyo Roshi Kaisya Ltd, Tokyo, Japan) and a membrane filter (0.45  $\mu\text{m}$ ; Millex-HV Filter Unit, Millipore Corp., Cork, Ireland). Filtrates were used to assay for ethanol, glucose and lactic acid concentrations.

Glucose and lactic acid concentrations of the filtrate were measured using portable devices – a glucose-measuring device (Glutest Ace®; Arkley, Kyoto, Japan) and a lactic acid-measuring device (Lactate Pro®; Arkley, Kyoto, Japan), respectively. Before measurement, the filtrate was diluted with 1.82 M sodium phosphate buffer (pH 7.4). Approximately 20  $\mu\text{L}$  of the sample was used for measurement. Correction calculations were made to determine the exact sample concentration.

To measure the ethanol concentration, the refractive index value of the obtained sample was measured using an Abbe refractometer (FHR-1; TGK, Tokyo). Since the refractive index value of the sample reflects ethanol content, the ethanol concentration was measured using the refractive index value and standard curves for ethanol; the ethanol–refractive index standard curve was plotted from known concentrations of ethanol. A pH meter (B-212; Horiba Ltd, Kyoto, Japan) was used to measure sample pH values.

## Results

Eight types of indigenous alcoholic beverages are produced in Andom village: palm wine (*melok alain*, *matango*), palm spirits (*kembé*), raffia wine (*melok asse*), cassava spirits (*mebwalam*), maize turbid beer (*mbwara*), maize spirits (*mebwalam*), plantain wine (*melok ykone*) and plantain spirits (*kembé ykone*). The method of production and chemical characteristics of each indigenous alcoholic beverage were investigated in this study.

### *Palm wine*

Palm wine was produced from palm sap. First, leaves of a palm tree were cut and removed, the tree was cut down, the top of the tree was tipped, and a bucket was attached to the top of the tree. Palm sap was exuded from the tip and allowed to flow into the bucket. Every day or half-day, palm sap was collected in the bucket and transferred to a plastic bottle. Exudation of palm sap continued for 3 or 4 weeks. Approximately 5 L of the sap could be obtained per day in the first week. In the second

week, exudation gradually decreased to approximately 1.5–2 L of sap per day. A few hours after collection in the bucket, the palm sap was sweet with a slightly alcoholic taste; after 1 day, an alcohol smell and taste were detected, indicating that alcohol fermentation had begun in the bucket, and palm sap was changed to palm wine. Alcohol fermentation was also recognized by bubble formation.

Palm sap collected on the first day was kept at an ambient temperature, and glucose concentration, lactic acid concentration and pH were measured every day (Fig. 1). Glucose concentration on the first day was approximately 40 mM, and it decreased quickly to reach a concentration of less than 1 mM on the second day (Fig. 1). Palm sap was sweet on the first day, but not on the second day. Initially, the lactic acid concentration was approximately 12 mM and the pH was around 4.2. The lactic acid concentration increased slightly and the pH decreased on the next day and on the third day (Fig. 1), suggesting that lactic acid fermentation occurred in the palm sap immediately after exudation and continued to some extent over the following days at a slow rate. This finding also suggested that the lactic bacteria and yeast inhabiting the tip of palm tree and/or the bucket, immediately proliferated in the palm sap to reduce the pH to around 4. The pH on the first day was already around 4, a condition under which most bacteria cannot survive but yeast and many other fungi can. It was assumed that, in this case, yeast would be present and this pH range was maintained during the fermentation. In the village, palm wine was consumed on the first or the second day. Older palm wine kept for more than 2 days was used for the production of palm spirit (described below).

Palm wine is the most popular alcoholic beverage in the village, with villagers consuming large amounts of palm wine on various occasions such as gatherings, meetings and funerals, and it is also offered to people who work in groups, for example, after working together in the fields.

### *Palm spirits*

Palm sap was obtained as described above and was left to stand for 1 day at ambient temperature to become palm wine. To 20 L of palm wine, 2 kg of sugar was added and mixed well, and this mixture was kept in a warm kitchen for 2 days. During this period, bubbling was observed. Distillation to enhance the ethanol concentration was carried out with a small (approximately 50 L volume capacity), simple and home-made distillation apparatus. Distillation was carried out for 2 h. Changes in the temperature of the cooling water were measured (Fig. 2).

Cooling water temperature at the beginning of distillation was 37°C and it was

increased to 40°C after 1 h of distillation, reaching 52.5°C at the end of distillation. Five litres of palm spirit were obtained from 20 L of palm wine. When sugar was not added, smaller amounts of palm spirit were obtained.

The glucose concentration of palm wine increased following sugar addition and decreased after 2 days of fermentation (Fig. 1). Ethanol, glucose and lactic acid concentrations and the pH value of palm spirit were recorded (Table 1).

At the beginning and the end of distillation, approximately 200 mL of distillate was collected to measure the ethanol concentration. The ethanol concentration of the palm wine was 13.6%, while that of the distillate at the beginning of distillation was 49.4%, which was higher than that of the distillate at the end of distillation (10.7%). The obtained distillate was combined, and the ethanol concentration of the final product was 34.2%. In palm spirit production, 1.71 L (1.349 kg) of alcohol was produced from 4.8 kg of carbohydrates. Thus, 49.2% of carbohydrates were converted into alcohol. The first distillate with a higher ethanol concentration is referred to as ‘premier’, and this is offered to neighbours and friends.

### *Raffia wine*

Raffia wine was produced from raffia sap obtained from the raffia palm tree (raffia tree). Unlike palm wine production, the raffia tree was not cut down to collect the raffia sap. To collect the raffia sap, a man climbed a raffia tree (approximately 10 m tall) and cut the trunk of the tree. A bucket was placed where the gash had been made to collect the sap exuded from the tree. Twice a day in the morning and evening, the raffia sap collected in the bucket was transferred into a plastic bottle. A maximum of 40 L of sap was collected each day. Raffia sap could be obtained for 4–5 weeks from a single raffia tree, following which the tree died. During the collection weeks, the quantity of raffia sap obtained each day was not reduced. The taste and odour of the raffia sap altered with time after collection. Sweetness was reduced, while the alcohol taste and odour increased. Raffia sap was converted to raffia wine. No raffia trees were planted in the village and raffia wine consumed in the village was brought in from a neighbouring village (Nika).

### *Cassava spirits*

Two methods are used in the village for the production of cassava spirits. Both methods require a cassava tuber to be conventionally processed into a lump of dry cassava from a raw cassava tuber, before the production of alcohol. Cassava tubers were pared with a knife, soaked in water for several days, allowed to undergo anaerobic

fermentation, mashed and then dried in the sun.

*First method of cassava spirit manufacture.*

Water (15.4 L) was added to cassava lumps (25.1 kg). Cassava lumps absorbed water and were placed in a nylon bag and then left in a warm location (kitchen) for 2 days. On the second day, a weight (heavy stone) was placed on the nylon bag to drain the water from the cassava lumps. Moist cassava lumps were roasted on a pan until the surface of the lumps became brown. During this step, the cassava lumps absorbed a large amount of water; starch granules of the cassava lumps swelled considerably. Under this condition, cassava starch was gelatinized by roasting, as the starch granules contained a sufficient amount of water for gelatinization. Gelatinization resulted in easy hydrolysis of the starch, which was saccharified by the amylase present in the germinated maize flour during the following process. Although most of the roasted cassava was used to manufacture cassava spirits, some portions were also eaten, with or without sugar, by the villagers.

After roasting, water (28 L) was added to the roasted cassava and the mixture was kept for 1 day at ambient temperature. After 1 day, germinated maize flour (2.1 kg) and water (25.5 L) were added to the roasted cassava lumps, which were mixed well and left to stand for 2 days at ambient temperature. The glucose concentration increased 1 day after adding the germinated maize flour (Fig. 1). This was the first ‘saccharifying step’. In this step, starch was degraded by the amylase present in the germinated maize flour. Separately, on the same day of adding water to the roasted cassava, round slices of banana (13.5 kg) and plantain (1.8 kg) were placed in a large metal pot and kept for 3 days. A smell of alcohol could be detected on the third day. Thereafter, the banana and plantain mixture was added to the cassava slurry together with sugar (1.9 kg) and kept for 3 days at an ambient temperature. After this addition to the slurry, the glucose concentration first increased and then decreased rapidly over time. During this period, bubbling occurred and a smell of alcohol was detected, indicating that the alcohol fermentation step had begun. In addition to the many types of saccharides produced through cassava starch degradation, various saccharides from banana, plantain and sugar were consumed by the yeast for alcohol fermentation. After 3 days of fermentation, the mixture was filtered through a punched metal plate. A turbid suspension containing ethanol was obtained, distilled and 17.9 L of cassava spirit was obtained from 137 L of fermented suspension.

At the beginning and the end of the distillation, approximately 200 mL of distillate was collected, and the ethanol concentration and pH of the distillate were

measured (Table 1). The ethanol concentration was higher at the beginning (28.6%) of distillation than that at the end (7.8%), which was similar to the trend observed with the palm spirit. The cooling temperature of the water increased with time (Fig. 2). In the production of cassava spirits, 4.03 L (3.18 kg) of ethanol was produced from 21.02 kg of carbohydrates. Thus, 21.4% of the carbohydrates was converted into alcohol.

### *Second method of cassava spirits manufacture.*

Cassava flour (4.9 kg), which was obtained by milling the dried lumps of cassava as described above, was added to the distillation dregs (39.6 L, 79.5°C) and stirred well. Thereafter, the cassava flour and dregs mixture was left to stand for 3 days in a warm location (kitchen). In this step, starch in the cassava flour was gelatinized because the temperature of the dregs was sufficiently high to gelatinize the starch. Because the dregs of the previous distillation contained a large amount of lactic acid and showed a low pH value (Fig. 1), contamination with harmful bacteria that could disturb alcohol fermentation was suppressed, providing suitable conditions for the growth of yeast.

After the first 3 days of the gelatinization step, germinated maize flour (2.7 kg), mashed banana (2.1 kg) and water (150 L) were added to the slurry, which was left to stand for 5 days at an ambient temperature. In this saccharifying step, the glucose concentration increased (Table 1), and other low molecular saccharides were probably produced. These saccharides could be used for fermentation by yeast, which was carried out continuously in the same slurry. At the beginning of the second day, bubbling was observed and an alcohol smell was detected, indicating that the alcohol fermentation had begun. During fermentation, the container containing the slurry was kept tightly closed, suggesting that the anaerobic conditions were purposefully maintained to promote the alcohol fermentation. Finally, the fermented slurry was distilled in a similar manner to the cassava spirit. In the second method of production of cassava spirits, 14.4 L of cassava spirits was produced from 206 L of fermented slurry.

Ethanol, glucose and lactic acid concentrations and the pH value of cassava spirits were recorded (Table 1). The ethanol concentration at the beginning of distillation (26.3%) was higher than that at the end of distillation and that of the final product, similar to the results observed in the production of palm spirit. At the end of distillation, the ethanol concentration decreased to 12.2%, while that of the final product was 20.7%. Temperature changes during the distillation process are shown in Fig. 2. The cooling water was changed twice during distillation to maintain the temperature below 78.4°C, which is the boiling point of ethanol. The ethanol concentration of the

final product during the first preparation of cassava spirits was higher than that of cassava spirits produced during the second method of production of cassava spirits. A large amount of saccharide sources were added over the course of the first preparation of cassava spirit production, relative to the second preparation method. Thus, a large amount of ethanol was produced during the first preparation of cassava spirit.

### *Maize turbid beer*

Although palm wine, palm spirits and cassava spirits are the major alcoholic beverages produced in the village, some villagers drink maize turbid beer and maize spirits, as well as plantain wine and plantain spirits.

Maize turbid beer was prepared as follows. Maize flour (14.7 kg) and water (25.0 L) were mixed and kept in a warm location (kitchen) in a metal pot on the first day. On the second day, moist maize paste was transferred to a nylon bag, on which a weight was placed to drain excess water for 1 day, similar to the preparation method for cassava spirit production. During this step, the starch absorbed water and became swollen. After 2 days, the maize paste was placed on a hot metal board for heating and roasting. This constituted the gelatinization step for starch. Roasted maize flour was also eaten directly, as occurred with cassava. After roasting, water (17.6 L) was added and the obtained slurry was left to stand for 8 h. Next, germinated maize flour (1.1 kg), dried dregs from a previous filtration (676 g) and water (18.4 L) were added to the slurry. The dried dregs from the previous filtration served as the source of yeast, and the villagers stated that the addition of dried dregs during the last filtration induced bubbling. The slurry was left to stand for 2 days. Bubbling was observed, and an alcoholic smell was detected. The change in the glucose concentration is shown in Fig. 1. Glucose in the slurry appeared to be converted to alcohol through the action of yeasts during this step, the fermentation step. The slurry was diluted by adding 13.2 L of water and consecutively filtered through a coarse sieve made from wood, as well as a fine sieve made from metal. The filtrate contained maize turbid beer and 48.8 L of maize turbid beer was thus obtained.

The ethanol, glucose and lactic acid concentrations and pH value of maize turbid beer were recorded (Table 1). The ethanol concentration was 2.50% and lactic acid concentration was 6.40 mM. Maize turbid beer was brownish and slightly sour. The villagers drink it at a warm temperature. Maize turbid beer was manufactured once per week and sold on the same day (every Thursday) in the village market. Maize turbid beer is typically consumed within one day of its production.

### *Maize spirits*

Water (40.0 L) was added to maize flour (53.8 kg), passed through a coarse sieve, and mixed well. This solution was left to stand for 2 days in a warm location (kitchen). After 2 days, the maize was roasted in the same manner as described above. Soaking in the water and roasting were referred to as the swelling step and gelatinization step for the starch granules and starch molecules of the maize, respectively. The roasted maize lump was eaten directly, as with the cassava spirit and maize turbid beer production process. After roasting, germinated maize flour (1.0 kg), dregs (17.6 L), the solid residue remaining after the last distillation and water (66.1 L) were added together to the roasted maize. The dregs had the same effects as described above. After leaving the mixture for half of a day, germinated maize flour (1.6 kg) was added, and the mixture was left to stand for 1 day. After that, germinated maize flour (900 g) was added again, and the slurry was left to stand for 1 day. Germinated maize flour (1.1 kg), banana (3.5 kg), sugar (2.0 kg), dried dregs from a previous distillation (150 g) and water (42.4 L) were added, and the slurry was left to stand for 2 days. On the second day, 1 kg of sugar was added, and the slurry was left to stand for 4 days in a container covered by a tight lid. Germinated maize flour and sugar were not added to the starchy slurry all at once, but rather at several intervals. This method was preferred as it prevented a reduction in the reaction rate owing to the inactivation of amylase in the germinated maize flour, and osmotic effects owing to a high sugar concentration. The method was used to maintain favourable growth and proliferation conditions for the yeast. Finally, the slurry was filtered and distilled, and the process for producing maize spirits was complete. A total of 18.5 L of maize spirit was produced from 195 L of slurry.

The ethanol, glucose, and lactic acid concentrations and the pH value of maize spirits were measured (Table 1). The ethanol concentration at the beginning of distillation was 45.9%, which decreased to 11.6% by the end of distillation. The ethanol concentration of the final product was 28.9%, which was higher than that of the cassava spirit. During maize spirit production, 5.35 L (4.22 kg) of alcohol was produced from 44.4 kg of carbohydrate (i.e. 15.2% of carbohydrates were converted into alcohol).

The temperature change during the distillation of the maize spirit is shown in Fig. 2. The temperature was kept below 78.4°C, which is the boiling point of ethanol, similar to that used in the production of cassava spirit.

### *Plantain wine*

Plantain is also one of the most important crops for supporting daily dietary life in this village. After ripening for 1 week after harvest, plantains (18 kg) were cut and



water (2 L) was added. During this time, the mixture of plantain and water was not stirred. After 1 day, hot water (2.65 L, 77.5°C) was added, and the mixture was left to stand for 1 day. Finally, the water was filtered through a cloth and the filtrate was consumed as plantain wine. During this period, fermentation occurred, ethanol was produced, and starch and sugar were consumed.

The ethanol, glucose and lactic acid concentrations and the pH value of plantain wine are shown in Table 1. The ethanol concentration of the plantain wine was low, while the glucose concentration was fairly high, resulting in a sweet beverage containing alcohol.

### *Plantain spirits*

Plantain spirit was prepared as follows. First, hot water (3.71 L, 75.5°C) was added to the plantain residue after making the plantain wine and the mixture was left to stand for 4 days, during which the glucose concentration in the supernatant decreased (Fig. 1), and an alcoholic taste and odour were detected. On the fourth day, 20 L of palm sap and 1.9 kg of sugar were added, and the plantain was mashed by hand. The slurry was stirred well and left to stand for 2 days. Finally, the slurry was distilled, and 5.38 L of plantain spirit was produced from 43.2 L of slurry.

The ethanol, glucose, and lactic acid concentrations and the pH value of plantain spirits were measured (Table 1). During distillation, the ethanol concentration was initially 47.4%, and decreased to 19.8% at the end. The initial ethanol concentration was the highest among all of the spirits produced in the village. Distillate was collected and mixed, and the ethanol concentration of the final product was 36.2%, which was higher than those of the other spirits. During plantain spirit production, 1.95 L (1.54 kg) of alcohol was produced from 4.70 kg of carbohydrates. Thus, 30.5% of the carbohydrate was converted into alcohol.

The temperature change during the distillation of plantain spirits is shown in Fig. 2. The temperature was maintained below 78.4°C, close to the boiling point of ethanol.

## **Discussion**

In the village, germinated maize was used as a source of amylase for the production of alcoholic beverages. The optimal temperature of  $\alpha$ -amylase from finger millet and sorghum, which are frequently used as amylase sources in the production of indigenous alcoholic beverages in sub-Saharan Africa, was in the range of 50–70°C (13,14). However, amylase from maize is inactivated by heating to 50°C, while



amylases from finger millet and sorghum are stable at 50°C (15). In the village, the slurry for alcoholic beverage containing germinated maize, which is the source of amylase, was not heated intentionally; this suggests that the villagers understood that the substrate (germinated maize amylase) was unstable above 50°C.

In the village, it took 5–7 days to prepare germinated maize. However, to increase the ethanol concentration of alcoholic beverages, a period of 5–7 days was not suitable because the activity of amylase from the maize was attained for a maximum of 4 days after germination (data not presented).

The pH of the dregs obtained in the last distillation, which were used for the next fermentation, was maintained below 5. Under this pH condition, proliferation and contamination of other bacteria could be repressed, more than the lactic acid bacteria and yeast would be suppressed. According to the villagers, the dregs obtained during the last distillation are important for a successful fermentation, because they accelerate the fermentation.

We clarified that the villagers made various efforts to enhance the quality of the alcoholic beverages, particularly the alcohol concentration. The quality of alcoholic beverages is important for producers to generate income and to maintain good relationships with neighbourhoods because alcoholic beverages are a source of reward for cooperative work and hospitality by hosts (e.g. for attending union meetings, among other reasons).

However, although these producers made various efforts to increase the ethanol concentration, the conversion efficiency from carbohydrates to ethanol was not high for cassava spirit and maize spirit, compared with that for palm spirits. In Andom village, germinated maize was used as a source of amylase in the cassava spirit, maize turbid beer and maize spirit production. However, maize has low amylase activity compared with finger millet and sorghum, which are generally used in the production of alcoholic beverages in sub-Saharan Africa (5,15). The low activity of the maize amylase is one of the causes of the low ethanol producing efficiency in both cassava and maize spirits production. Starch in cassava and maize are not saccharified efficiently by the germinated maize in the production of spirits from these substrates.

In the northern region of Cameroon, sorghum turbid beer known as '*bili bili*' is produced and consumed (16). Sorghum turbid beer provides one-third of the total energy consumed yearly in the Koma society in the northern region of Cameroon (7). In these regions, sorghum is the most important staple food, and most ritual ceremonies are accompanied by the consumption of sorghum turbid beer (7). However, in Andom village, the alcoholic beverage made from starchy materials, such as maize turbid beer,

did not have any social importance. In Andom village, palm wine was the most important alcoholic beverage, and it was the main one used during every social occasion.

In Andom village, the technique for producing alcoholic beverages from starchy materials was not improved compared with that used for palm sap. In addition, non-alcoholic beverages produced from starch did not occur in the village. Starch-based nonalcoholic beverages, known as '*Togwa*', are popular in a local area of Tanzania. This beverage is produced as a nourishing drink for children, the elderly and the sick, or as an energy drink for field labourers in Tanzania (14, 17). Similar non-alcoholic beverages are produced and consumed in some villages in Zambia (18). In these regions, stiff porridge (*Ugali* in Swahili), porridge (*Uji*), a nonalcoholic beverage (*Togwa*) and an alcoholic beverage (*Pombe*) are produced using a single type of cereal that is a staple crop of the region. This '*Ugali–Uji–Togwa–Pombe* pathway' is widespread in the cereal agriculture region of sub-Saharan Africa, where cereals such as finger millet and sorghum are produced at high levels and root crops such as cassava are rarely produced.

In the cereal agriculture region of sub-Saharan Africa, stiff porridges made from finger millet, sorghum and maize are eaten as staple foods together with cowpea, with kidney beans consumed as a side dish. In contrast, in Andom village, in which cassava is a staple crop, beans are rarely eaten, and animal protein such as bush meat, fish and insects is typically consumed. These foods, which are generally obtained by hunting, fishing and gathering, are necessary to meet nutritional demands. Another research survey in the cassava-producing region of the South Cameroon showed that approximately 80% of total protein intake was from animal products (19).

The environment of Andom village is rich in food resources, and activities such as hunting, fishing and gathering are well developed. Palm sap, which is a material used to produce the most important alcoholic beverage in this region, can also be obtained by gathering in the forest; palm sap changes to palm wine naturally without the involvement of complicated techniques. However, obtainable food resources are limited in the cereal agriculture region compared with the root crop agriculture region, and the technique utilizing a single type of food material such as in the '*Ugali–Uji–Togwa–Pombe* pathway' should be further developed.

In addition, finger millet and sorghum, which show high amylase activity, were not cultivated in Andom village. Therefore, maize, which has low amylase activity, was used as an amylase source for alcoholic beverages produced from starch. However, it is difficult to produce alcoholic beverages with a high ethanol concentration using germinated maize as an amylase source. Therefore, the villagers produced distilled

alcoholic beverages to increase the ethanol concentration, resulting in a high-quality alcoholic beverage. In African society, strong and opaque alcoholic beverages are generally preferred (1).

## Conclusions

In Andom village, many types of alcoholic beverage made from various materials are produced and consumed. In these alcoholic beverages, palm wine is the most important for solidarity confirmation, religious rituals, remuneration for group labour work and income generation. In contrast, starch-based alcoholic beverages are used for producing spirits, and are not important except as a refreshment and source of income. In addition, by-products of these starch-based alcoholic beverages are not utilized. In contrast to the cereal agriculture region, a technique for processing cereals is not well developed in the root crop agriculture region, such as Andom village; in this village, plentiful food resources can be obtained by hunting, fishing and gathering, not only for daily foods, but also for the production of alcoholic beverages.

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## Captions

Figure 1. Change in glucose concentration (A), lactic acid concentration (B) and pH (C) of palm wine and palm spirits (●), cassava spirits 1 (▲), cassava spirits 2 (■), maize turbid beer (○), maize spirits (Δ) and plantain spirits (□).

Figure 2. Change in the temperature of cooling water during distillation: palm spirits (●: from 20.0 L unrefined to 5.00 L of the product); cassava spirits 1 (▲: from 101 L unrefined to 7.00 L of the product); cassava spirits 2 (■: from 30.6 L unrefined to 4.00 L of the product); maize spirits (&: from 45.4 L unrefined to 4.30 L of the product), and plantain spirits (□: from 43.2 L unrefined to 5.38 L of the product).

Figure A1. Method of production of cassava spirits 1.

Figure A2. Method of production of cassava spirits 2.

Figure A3. Method of production of maize turbid beer.

Figure A4. Method of production of maize spirits.

Figure A5. Methods of production of plantain wine and spirits.

Figure A6. The homemade distillation apparatus in Andom village. The slurry containing alcohol is cooked in a pot (the rear) and the vapor passes through the tube. When the vapor passes through the tube, it is cooled by water in the tub (the front) and the distillate come out of the end of the tube.

Table 1. The pH and ethanol, glucose, and lactic acid concentrations of indigenous alcoholic beverages from a rural village in Cameroon

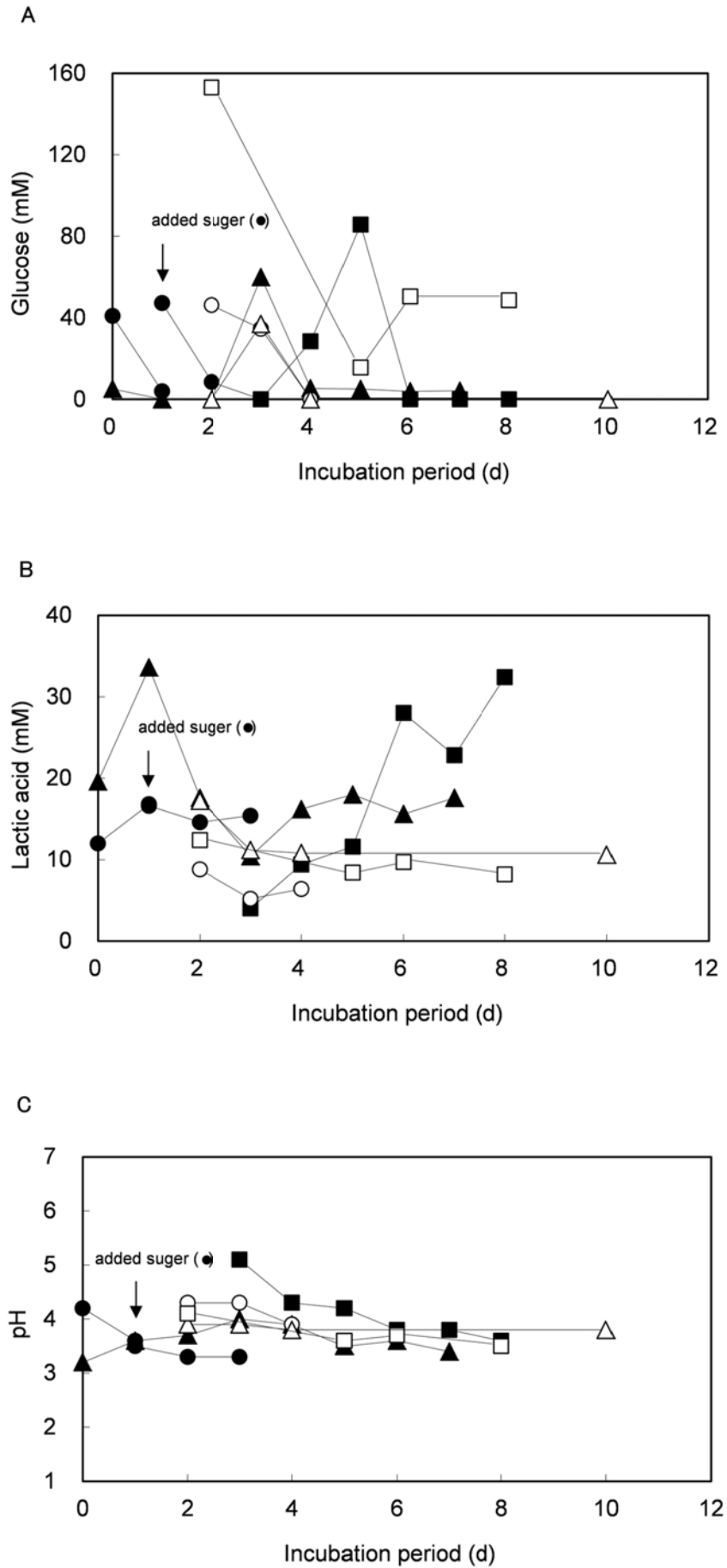


Figure 1

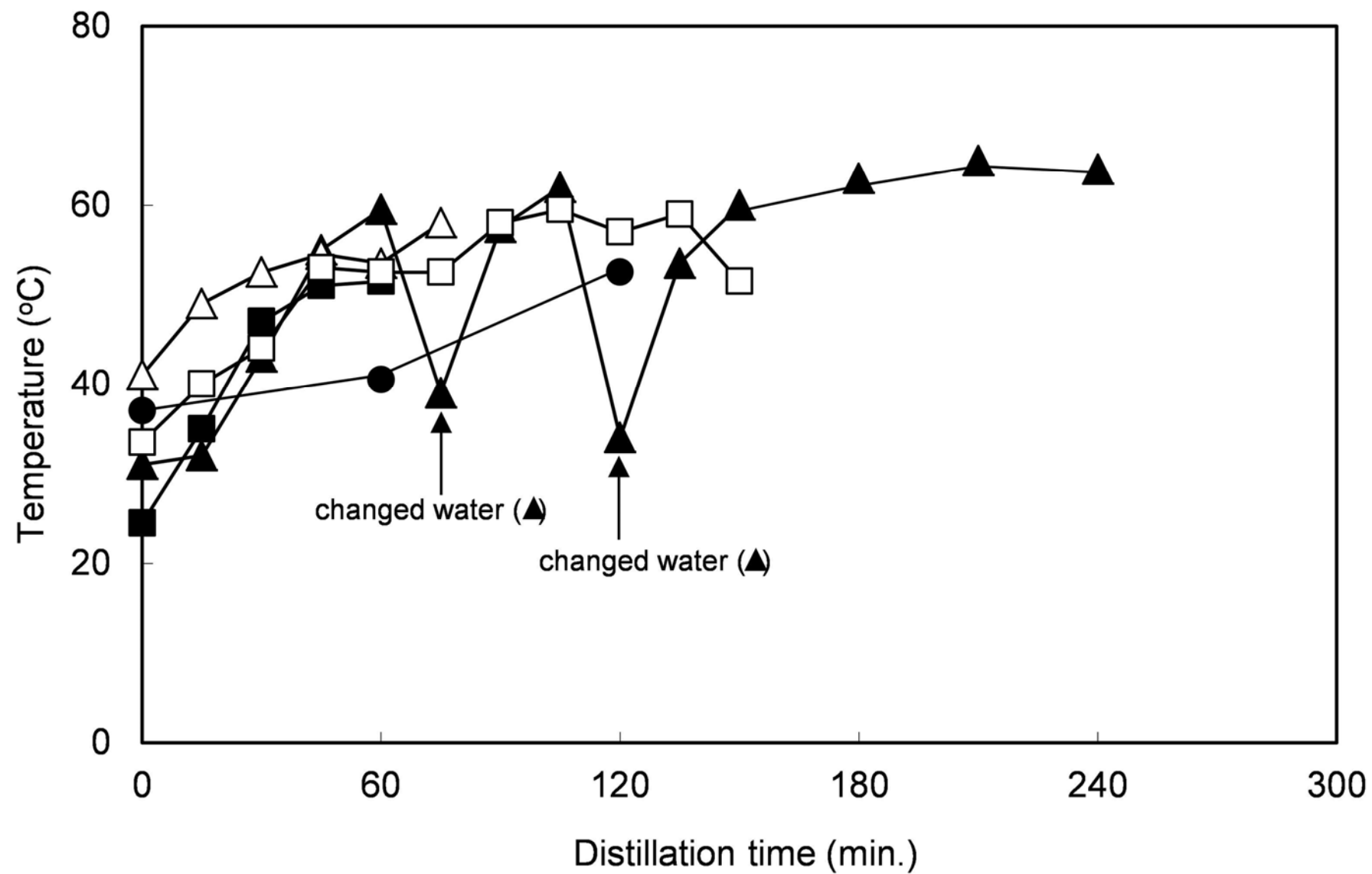


Figure 2

the dried cassava (25.1 kg)

- added water (15.4 litres)
- left for 2 d
- roasted
- added water (28.0 litres)
- stirred
- left for 1 d
- added the germinated maize flour (2.1 kg)
- added water (25.5 litres)
- stirred
- left for 2 d
- added the fermented banana and plantain mixture\*
- added sugar (1.9 kg)
- stirred
- left for 3 d
- filtrated
- distilled

cassava spirits

cut banana (13.5 kg)

- added cut plantain (1.8 kg)
- left for 3 d

the fermented banana and plantain mixture\*

Figure A1



the dregs of the last time distillation (39.6 litres, 79.5°C)

- added the cassava flour (4.9 kg)
- stirred
- left for 3 d
- added the germinated maize flour (2.7 kg)
- added banana (2.1 kg)
- added water (150 litres)
- stirred
- left for 5 d
- distilled

cassava spirits

the maize flour (14.7 kg)

- added water (25.0 litres)
- stirred
- left for 2 d
- roasted
- added water (17.6 litres)
- left for 8 h
- added the germinated maize flour (1.1 kg)
- added the dried dregs of the last time filtration (676 g)
- added water (18.4 litres)
- stirred
- left for 2 d
- added water (13.2 litres)
- filtrated with the coarse sieve
- filtrated with the fine sieve

maize turbid beer

the coarse maize flour (53.8 kg)

- added water (40.0 litres)
- stirred
- left for 2 d
- roasted
- added the germinated maize flour (1.0 kg)
- added the dregs of the last time distillation (17.6 litres)
- added water (66.1 litres)
- left for half d
- added the germinated maize flour (1.6 kg)
- stirred
- left for 1 d
- added the germinated maize flour (900 g)
- stirred
- left for 1 d
- added the germinated maize flour (1.1 kg)
- added banana (3.5 kg)
- added sugar (2.0 kg)
- added the dried dregs of the last time filtration (150 g)
- added water (42.4 litres)
- stirred
- left for 2 d
- added sugar (1.0 kg)
- stirred
- left for 4 d
- filtrated
- distilled

maize spirits

Figure A4

cut plantain (18.0 kg)

- added water (2.00 litres)
- left for 1 d
- added hot water (2.65 litres, 77.5°C)
- left for 1 d - filtrated - plantain wine
- added hot water (3.71 litres, 75.5°C)
- left for 4 d
- added palm wine (20.0 litres)
- added sugar (1.9 kg)
- stirred
- left for 2 d
- distilled

plantain spirits



Figure A6

		pH	ethanol (%)	glucose (mM)	lactic acid (mM)
palm wine	the product	4.3	4.5	70	16.8
	the beginning	4.7	49.4	< 1.10	< 0.80
palm spirits	the ending	3.1	10.7	< 1.10	< 0.80
	the product	3.5	34.2	< 1.10	< 0.80
	the beginning	3.7	26.3	< 1.10	< 0.80
cassava spirits (1)	the ending	3.9	12.2	< 1.10	< 0.80
	the product	3.4	20.7	< 1.10	< 0.80
	the beginning	4.3	28.6	< 1.10	< 0.80
cassava spirits (2)	the ending	3.5	7.8	< 1.10	< 0.80
	the product	3.7	22.5	< 1.10	< 0.80
maize turbid beer	the product	3.9	2.5	< 1.10	6.4
	the beginning	4.2	45.9	< 1.10	< 0.80
maize spirits	the ending	3.2	11.6	< 1.10	< 0.80
	the product	4.1	28.9	< 1.10	< 0.80
plantain wine	the product	4.1	-	153	12.6
	the beginning	4.4	47.4	< 1.10	< 0.80
plantain spirits	the ending	2.8	19.8	< 1.10	< 0.80
	the product	3.3	36.2	< 1.10	< 0.80

Table 1